adjusted to an odd number of μ/4 layers such as for the simple anti-resonant microcavity, but the exit region **14** further comprises a bragg mirror with about 1 to 15 pairs of layers of higher and lower indices of refraction (instead of a simple transition between mediums of different indices of refraction such as for the simple anti-resonant microcavity). This is the variant shown on FIG. **10**.

[0189] FIG. **11** shows a calculated reflectivity or gain spectrum **40** (in percent) in function of the wavelength (nm) of an enhanced anti-resonant structure such as shown on FIG. **10**.

[0190] As explained before, the gain spectrum **40** results from the intrinsic gain curve of the quantum wells, modified by the enhanced anti-resonance characteristics of the microcavity formed by the partial Bragg mirror of the exit region **14** and the first mirror **12**.

[0191] FIG. **12** shows an enlarged view **41** of the gain curve around the operating wavelength λ.

[0192] The result of both first, second and third variant is to obtain a broad spectral gain curve, which corresponds to the spectral gain curve of the quantum wells in the case of the anti-reflective coating, a broader curve when using the anti-resonance condition, and a still broader curve when using the enhanced anti-resonance condition (FIG. **11** and FIG. **12**).

[0193] It also allows reducing the Laser field intensity in the structure to increase the cavity finesse, reduce the thermal lens strength and thermal noise induced frequency noise. The finesse can be for instance increased by a factor of 3 for an anti-resonant design, the thermal lens reduced by 3, and the frequency noise spectral density reduced by 10 compared to a design with an antireflection coating.

[0194] By doing so, a HWHM gain bandwidth of 5 to 10 THz may be achieved.

[0195] The length of the external cavity is set around 0.3 mm, which corresponds to a FSR of 500 GHz.

[0196] So, the spectral ratio between the Half Width Half Maximum (HWHM) spectral bandwidth of the modal gain and the free spectral range of the external cavity is between 10 and 20.

[0197] The second mirror **12** is a concave mirror with a transmittance T=1% (or 0.3% for an anti-resonant design).

[0198] This configuration allows broad continuous laser frequency tunability (without mode hops), larger than 500 GHz at constant power, thanks to Piezo-based cavity length tuning. A frequency tunability of more than 500 GHz may also be achieved by combining piezo displacement of the second mirror **16** and tuning of the temperature of the semiconductor element **10**.

[0199] A broader frequency tunability is even possible with mode hops.

[0200] The external cavity has a high finesse, superior to 600 (or 2000 for an anti-resonant design).

[0201] This configuration allows achieving:

[0202] a Side Mode Suppression Ratio at Quantum limit >45 dB.

[0203] a Polarization Extinction Ratio at Quantum limit >55 dB;

[0204] a weak Class B laser dynamics, with weak relaxation oscillations below 10 dB in RIN;

[0205] a good temporal coherence: RIN cavity cutoff of 500 MHz (or of 150 MHz for an anti-resonant design),

shot noise 500 MHz (150 MHz for an anti-resonant design), linewidth 100 kHz (1 ms) with Quantum Limit<100 Hz;

[0206] a moderate output power (>5 mW without thermal management, >50 mW with structure bonded on high thermal conductivity substrate like Diamond or gold)

[0207] a beam quality M2<1.5.

[0208] FIG. **13** illustrates an example of Relative Intensity Noise (dB/Hz) at quantum limit (pump RIN<−152 dB) plotted in function of the radio frequency RF (Hz), obtained with a device of the invention with a 0.3 mm long anti-resonant cavity emitting 5 mW at 2.3 μm. It can be seen that the shot noise for 1 mA of photocurrent is reached at 500 MHz here.

[0209] FIG. **9** illustrates an example of Frequency Noise Spectral density (Hz²/Hz) at quantum limit plotted in function of the radio frequency RF (Hz), obtained with a device of the invention with a 0.3 mm long anti-resonant cavity emitting 5 mW at 2.3 μm. The fundamental laser linewidth (FWHM) is thus 147 Hz here.

[0210] As an example of such designs of the laser device according to the invention, the following configurations may be implemented:

[0211] a simple antiresonant design, as illustrated in FIG. **15**, with an odd number of λ/4 layers (equal to 15 in FIG. **16**) located between the substrate and the caping layer, and without a Bragg mirror onto the top surface of the microcavity. It provides a broad tunable laser, with a large bandwidth, for which the ratio between the light power inside the optical microcavity and the light power inside the external cavity is equal to 0.3. The length of the external optical cavity may be typically included between 0.4 mm and 1 mm, which leads to a Free Spectral Range in the range of 150 GHz to 375 GHz and a net bandwidth comprised between 1 THz and 6 THz. FIG. **16** shows the ratio between the light power inside the gain structure and through the external cavity as a function of wavelength for such simple antiresonant design: as visible, the ratio is equal to 0.29 for λ=1000 nm. As explained before, it results from the intrinsic gain curve of the quantum wells and the length of the microcavity. FIG. **17** illustrates the electrical filed density across a simple antiresonant laser device.

[0212] an enhanced antiresonant design, as schematically illustrated in FIG. **18** with an odd number of λ/4 layers (equal to 15 in FIG. **18**) located between the substrate and the caping layer, and with a Bragg mirror onto the top surface of the microcavity, composed with a pair number of λ/4 layers comprised between 1 and 10. Thus, the optical bandwidth of such design is broader than the modal gain bandwidth in order to keep antiresonance condition across the full gain bandwidth and to allow broad temperature-based wavelength tuning. In this case, the ratio between the light power inside the optical microcavity and the light power inside the external cavity is equal to 0.1. The length of the external optical cavity may be typically included between 0.2 mm and 1 mm, which leads to a Free Spectral Range in the range of 150 GHz to 750 GHz and a net bandwidth comprised between 1 THz and 6 THz.